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IRON-55 IN RONGELAP PEOPLE, FISH AND SOILS

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Abstract—The ^{55}Fe body burdens for 60 residents of Rongelap Atoll are reported. The measured burdens are approximately 3 times higher than those of a similar number of residents from Tokai-mura, Japan. Since previous measurements in 1966 revealed substantial ^{55}Fe body burdens in Japanese residents, the current Rongelapese ^{55}Fe body burdens pose interesting questions.

INTRODUCTION

SINCE 1965, the distribution of ^{55}Fe in the biosphere has been studied both in the United States and in the Scandinavian countries. Initially, ^{55}Fe concentrations were determined in Alaskan Eskimos, residents of Richland, Washington, and in representative foodstuffs of both.[1] Subsequently, ^{55}Fe concentrations in environmental samples and in residents of Finland[2] and Sweden[3] were reported which generally confirmed the findings of the earlier study. Additional research shows that (i) marine organisms and people whose diet is largely seafood contain the highest concentrations of ^{55}Fe;[4] (ii) residents of the northern hemisphere have higher ^{55}Fe body burdens than those of the southern hemisphere;[5] and (iii) the ^{55}Fe levels in people reached peak concentrations in 1966 and continue to decrease.[6,7] JAAKKOLA[8] has recently presented an excellent summary of the measurements of ^{55}Fe in Finnish Lapps which includes a valuable bibliography.

We determined the ^{55}Fe body burdens of natives at Rongelap Atoll in the Marshall Islands. Our interest in this particular population derives from two important considerations. First, the Rongelapese are a maritime culture, and they derive a large portion of their diet from the sea.[9] Prominent in this diet are the reef fishes; goatfish (*Mulloidicthys, sp.*), mullet (*Neomyxus, sp.*) and surgeon-fish (*Acanthurus, sp.*). Estimates of fish consumption vary, but daily intakes between 75–150 g appear reasonable. There are no apparent qualitative differences in the diets of males or females. Thus, the determination of ^{55}Fe in this population is of interest for comparison with other maritime cultures. Second, Rongelap Atoll received high-level fallout following the detonation of a thermonuclear device at Bikini Atoll in 1954.[10] We considered it probable that retention of ^{55}Fe at the atoll from that event, coupled with input from world wide fallout from large-scale nuclear device testing in 1961–1962 might lead to elevated concentrations of ^{55}Fe in marine species in the Rongelapese diet and therefore unusual body burdens of this radionuclide in Rongelap residents.

METHODS AND TECHNIQUES

The method of separation of ^{55}Fe was identical to that previously described.[1] The counting technique was changed slightly; a gas filled (Xe) proportional counter operating in anticoincidence with an umbrella of nine Geiger–Müller tubes was used to detect the 5.9-keV X-ray emitted in the electron capture decay of ^{55}Fe. Pulses from the proportional counter were recorded in a 512-channel multichannel analyzer. The detection system was surrounded by 4 in. of lead shielding and the resultant background counting rate under the ^{55}Fe photopeak was 1.7 counts/min^{-1}.

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PERSSON[12] in his estimate of ^{55}Fe body burdens in Lapps of Northern Sweden. Previous estimates of body burdens from composite blood specimens[1,5] were made assuming that the average total blood volume was 5 l. and that 60 % of the total iron is in the blood. Using this method with the Rongelap data, the average ^{55}Fe body burdens agreed within 15 % of those calculated using body weights.

RESULTS AND DISCUSSION

Table 1 gives the average body burdens of ^{55}Fe in the group of Rongelapese sampled in

[redacted]

The maximum body burden in the males was 0.85 μCi, while 3 females had body burdens greater than this value. The maximum observed female body burden was 1.0 μCi,

Table 1. *Average* ^{55}Fe *body burdens of Rongelapese*

Date sampled	No. of subjects/sex	^{55}Fe (μCi)*
March 1970	28/M	0.43 ± 0.17
March 1970	32/F	0.40 ± 0.27

* Standard error (1σ) of the mean.

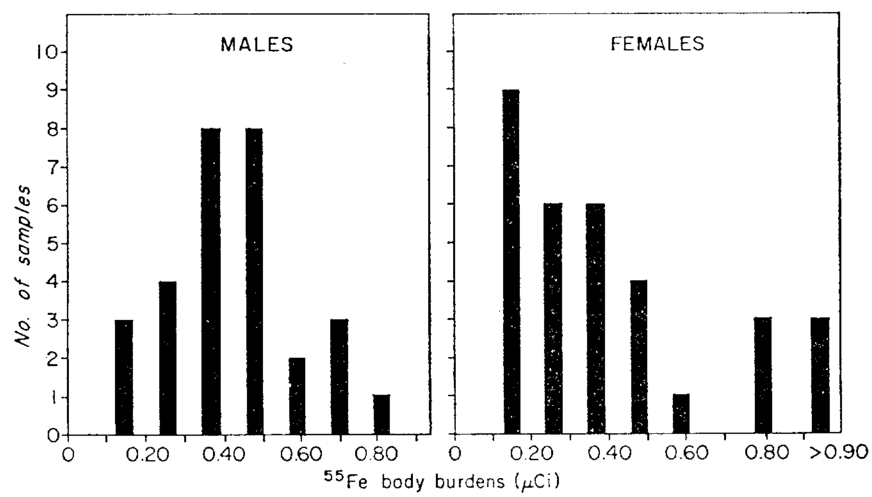

FIG. 1. Frequency distribution of ^{55}Fe body burdens in Rongelap males and females. Body burdens have been grouped into classes. Example: 3 Rongelap males had ^{55}Fe body burdens between 0.10–0.20 μCi while nine females had ^{55}Fe body burdens in the same activity interval.

[redacted]

the general increase of ^{55}Fe body burden with age appears qualitatively consistent with earlier data obtained by analyzing blood from Seattle, Washington males in 1966.

Comparison of the ^{55}Fe body burdens of peoples of different countries[5] requires knowledge of the turnover rates of ^{55}Fe in the environment and in humans. JENNINGS[14] has shown that the ^{55}Fe specific activities of salmon taken

Table 2. Average body burden of ^{55}Fe *in Rongelapese residents of different ages*

	Age	Number of samples	Body burden (μCi)
Males	16–20	8	0.31
	21–31	4	0.33
	32–42	5	0.52
	43–53	2	0.58
	54–64	6	0.53
	>64	3	0.48
Females	16–20	6	0.23
	21–31	12	0.34
	32–42	5	0.33
	43–53	7	0.66
	54–64	2	0.57
	>64	2	0.66

[redacted] determined the ^{55}Fe body burdens of 32 females and 37 males from Tokai-mura from blood collected in October 1970; the average values were 0.12 and 0.17 respectively. Thus, not only do the Rongelapese have significantly higher ^{55}Fe body burdens than those of the Tokai-mura residents, but the decrease in the ^{55}Fe body burdens of this latter group from 1966 to 1970 appears comparable to that for Richland, Washington, males.

As previously stated, all of the donors of the Rongelap study were subjected to external radiation during the accidental contamination of Rongelap Atoll in 1954. Because of the high levels of radioactivity at the Atoll, the Rongelap natives were moved to Majuro Atoll where they resided for 3.5 yr. Following exposure in 1954, whole body counting and urinalysis disclosed measurable quantities of internally deposited fallout radionuclides. By 1957, however, the only radionuclides present in the Rongelapese in significantly measurable quantities were ^{65}Zn, ^{137}Cs and ^{90}Sr.[10] No ^{55}Fe analyses were performed at that time so body burdens of this radionuclide are not known. However, based [redacted] 1957. Whole body counting and urinalysis measurements one year later disclosed increased body burdens of several radionuclides, the most notable being ^{137}Cs. It is probable that ^{55}Fe body burdens increased similarly.

The concentrations of ^{55}Fe in a selected species of fish and in the calcareous soils are listed in Table 3. Activity in the fish is based on wet weights for comparison with previous work. The amount of sample that was available for analysis was small and therefore it was necessary to combine individual samples. This prevents an estimate of the range of ^{55}Fe concentrations which occur between fish, i.e. the within sample variation. The number in parenthesis in Table 2 for the biological samples indicates the number of fishes which contributed to the pooled, single sample analyzed. The ^{55}Fe values for soil samples collected in 1963 at both Kabelle Islet and Rongelap Islet are averages of samples collected at depth increments of 0–1.3 and 1.3–2.5 cm. Specific activities are *not* given for soils since varying amounts of pre-1954 [redacted] better index of changes which occur as a result of input or loss than is specific activity.

The decrease in ^{55}Fe specific activities in *Mulloidichthys, sp.* (goatfish) at Rongelap between 1959–1961 corresponds to an ecological half-life of 11 *months*, identical to that observed by Jennings.[14] Higher specific activities may have occurred at earlier times; however, estimates based only on exponential loss would not take into account possible retention and cycling of ^{55}Fe within the lagoon, or the time lag between deposition and maximum specific activity in the aquatic biota.

The increase in specific activity of goatfish liver between late 1961 and mid 1963 reflects the increased environmental concentrations of ^{55}Fe resulting from testing nuclear devices in 1961–1962. Introduction of this radionuclide to Rongelap Atoll can occur both by atmospheric fallout and by water transport of radioactivity from oceanic regimes. The westward-moving North Equatorial Current is comprised of waters from northern latitudes where fallout from the of immature and mature goatfish liver collected at Johnston Atoll in 1968 showed that immature fish livers contained less stable iron and more ^{55}Fe per unit wet weight than did livers from mature fish. We assume that the immature fish are in the process of forming their iron stores and therefore more nearly reflect the environmental specific activities than do the mature fish whose iron stores are already formed. In the latter case, exchange rates may be slow.

Our measurements of ^{55}Fe in soils collected from the same sites between 1959–1963 do not clarify either of the input sources mentioned above; the changes in concentrations are greater than can be accounted for by physical decay. Natural processes which remove ^{55}Fe from the upper 2.54 cm of soil may preclude its use as a precise collector, and therefore the results are useful only to indicate order of magnitude values of ^{55}Fe soil concentrations present at the collection time.

Unfortunately it is not possible to offer a clear argument in explanation of the ^{55}Fe body burdens of the Rongelapese presented here, at this time. Samples from 1963 through 1969 would have shed light on the problem, but none are available for analysis. In a speculative vein, several explanations can be advanced. First, the possibility of Rongelap lagoon acting as a nutrient and trace-element "trap" similar to estuaries[18] is intriguing. Removal and retention within the lagoon of both stable iron and ^{55}Fe from the North Equatorial Current could lead to high specific activities of ^{55}Fe in ocean current systems feeding the North Equatorial Current (in addition to biological and physico–chemical factors) will deplete northern waters of this radionuclide. As discussed earlier, transit time for these waters from high latitudes to Rongelap Atoll is measured in year, and it is therefore possible that the higher ^{55}Fe body burdens in the Rongelapese reflects a "lag" time between the ^{55}Fe specific activities of Northern Pacific and Southern Pacific Ocean biota due to this transport. Finally it is possible that the high ^{55}Fe Rongelapese body burdens relative to the Japanese donors results from a combination of dietary intake and uptake and retention differences for iron between the two groups sampled. Unfortunately precise dietary information for both groups is lacking and little is known about the ^{55}Fe specific activities of the foods eaten by both groups. The Rongelapese do not suffer from iron deficiency anemia, so enhanced uptake of iron from the diet is probably inconsequential. It is clear that further measurements of the specific activities of ^{55}Fe in the diets of the Rongelapese and other maritime cultures and the effective half-life they display for this radionuclide will be needed to clarify the questions raised here.

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tains a brief review of past medical surveys on Rongelapese natives and a bibliography listing medical reports, radioecological studies, and graduate theses which deal with work conducted at Rongelap Atoll.

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